Radar technique for the study of structure and dynamics of the hail-storm processes

Kh.A.Imamdjanov
Centre of Hydrometeorological Service at the
Cabinet of Ministers of the Republic of Uzbekistan

Complex of atmospheric phenomena (as stormy winds, gusts, hail, thunderstorms, etc.) is related to convection. The most dangerous of them are the hail and showers which cause the floods and wash out of soils from agricultural fields. Since 60s of XXc. in Uzbekistan the measures against the hail began to be introduced. The radar stations (RS) were used for those measures and demonstrated the possibilities of the investigation of structure and dynamics of the convective cloud.

The radar equipment as a measuring system has a fixed range of linear dimensions being detected by the clouds (cells). The working out of the inner structure in detail makes the overall area of the detection of the cloud system and thickness of the atmospheric layer narrower. The other contradictions in the demands to the measuring techniques are also revealed in the use of the hail processes. The process of development is rather short (30-90 min.). For the study of the processes dynamics it is needed to have at least 5-7 moments of the "instant" survey of clouds with the linear dimension of 20-150 km and volume of $10^7 – 10^{10}$ m^3.

In this concern, the main task of the radar observations is to get the three-dimension pattern of the cellular structure of the hail-storm clouds and its temporal evolution.

For this the photographic registration of the radar echo pattern was made with the indicator of circular view (ICV) and indicator of "distance – attitude" (IDA) with the different angles of aerial incline and different azimuth. The angle of the aerial incline was selected with the purpose to get the pseudo-horizontal sections of the strongest convective cells or of the centre of the hail-storm process at 1, 3, 6, 9 and 12-km atmospheric layers a.s.l. After the photo-survey of the radar echo on ICV the photographic registration of radar echo pattern was made on IDA in the azimuth of the maximum radar echo of convective cells and zone of the weak radar echo which corresponds to the zone of updroughts feeding the strong convective cells. The photographic survey on ICV and IDA was carried out within the iso-contours of the radar intensity by the step-by-step regulation of intensification of ULF of the radar receiver or by the introducing of attenuation in VHF-tract in the output of the receiver every 12db. Afterwards the measurements of the maximum radar characteristics of the convective cells: radar reflectivity (η cm^{-1}), height of the position of the radar echo maximum (H_{max}, km), elevation of the zone of the intensified radar echo (H , km) and height of the upper limit of the radar echo (H , km) was made.

The photographic registration of the radar echo pattern on ICV, IDA as well as the measurement of the maximum radar characteristics compiled one series. (Fig.1) After the completion of one series the next one began immediately. The duration of one series of observations was about 7 – 10 min. Such time interval provides for the more or less successive pattern of radar echo from one series to another. Then it makes it possible to follow the transformation of their structure and dynamics of their development when analyzing the temporal evolution of the hail clouds and separate convective cells. The observations were conducted during the whole period of development of the hail-storm processes within 100km radius. 10 – 40 series of observations were made during the period of the hail-storm processes development.

On the base of results of photographic registration on ICV the patterns of radar eco of the hail-storm processes were made in a form of pseudo-horizontal cross-sections at the height of 1, 3, 6, 9 and 12 km a.s.l. at one scale of the multi-contour iso-echo every 12 db. The radar-echo patterns for the different height were created using the superimposing of their spatial position in such a way which allows to follow the tilt of the cells and change of their configuration with elevation. Under the radar-echo pattern the characteristic structure of it on IDA was placed on ICV also in a form of a multi-contours iso-echo, every 12 db.

Similarly, the radar-echo pattern resulted during the observations of the successive series were adjusted one with another taking into account the spatial position of the convective cells to provide a visual understanding of the direction of displacement of the whole hail-storm process and its separate convective cells.

Using the information about the successive positions of the cloud system and convective cells the pattern of trajectories of the whole process and of its separate convective cells was created. The vector of the leading flow revealed as the vector of the medium wind at 700 and 500 hPa surfaces was defined. The analysis of such patterns makes it possible to study the joint positions of the leading flow vectors and movements of the hail-storm clouds in a whole and its separate convective cells. It also gives an idea about the behaviour of as spatial extension of the precipitation-forming process (permanently, discretely-permanently and discretely). Besides, the possibility is given to follow the regularity and location of origination of radar-echoes of new convective cells, etc.

Automatic meteorological radar MRL-5 is designed on the obtained results. It fulfils the following operations:

- identification of the weather phenomena
- forecasting the dynamics of the weather phenomena development during 5, 10, 15 and 20 minutes
- showing the spatial pattern of the cloud and precipitation fields on the background of the locality map at the distance up to 240 km
- chart of the severe weather phenomena (gusts, thunderstorm, hail, shower, etc.) on the background of the map of administrative borders, regions, etc.
- evolution of the cloud processes, direction and speed of the cloud movement, cloud systems and severe weather phenomena
- chart of the fields of precipitation intensity and quantity at the distance up to 150 km
- measurement of the cloud parameters at the distance up to 150 km
- controlling the operations on the weather modification
- distinguishing between the objects of modification
- controlling the results and evaluation of the effectiveness of the weather modification
- print out the information by the user request
- archiving and representing of all collected information
- transfer of the received information to all interested users

Using the radar data, the parametric model of cloudiness of a hail cloud was developed which gives the possibility to detect the evolution of cloudiness and cells, phases of their development, age and dissipation, cloud types, etc.

Finally we would like to mention that the developed radar technique of the hail-storm processes observation is successfully being used at the hail-suppression teams of Uzbekistan, Tajikistan and Northern Caucasus.